DRAFT - FOR REVIEW ONLY

HOT: ONE WORLD, ONE CLIMATE ROLE PLAY SIMULATION

Climate Challenge

Civilization has developed, and constructed extensive infrastructure, during a period of unusual climate stability, the Holocene, now almost 12,000 years in duration. That period is about to end.

- James Hansen, Climate Scientist, Columbia University Earth Institute

Hot: One World, One Climate

Role Play Simulation

Developers and Authors

Carolyn Harris, Pushker Kharecha and Ryan Goble

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INTRODUCTION

What if our world's climate was 3°C warmer? Would your life and life around the planet be different?

Over the past century Earth's average temperature rose by 0.8°C hotter and continues to rise. Scientists agree that we are living in a time of significant global climate change. We are already seeing some of the affects of living in a warmer climate. These include: water and food shortages, increasing frequency of destructive weather, wildfires, sea level rise, forced migration, heat-related health issues, species and ecosystem loss and more. The planet's temperature will continue to rise if we keep adding atmospheric greenhouse gases like carbon dioxide by burning fossil fuels (coal, oil and gas) to meet most of our energy needs.

It is today's youth and future generations who will likely face the worst impacts if the global situation stays on its present course. Can we prevent global climate change from developing into a crisis? The Climate Challenge creates a simulated situation for youth to seize a moment when leaders give them a chance to turn one of the greatest challenges of our time – global climate change – into the greatest opportunity for their generation.

The Simulation: We created the Climate Challenge as a global situation to immerse students in learning about climate change, thinking about its implications and evaluating and designing possible solutions. In this alternate reality scenario, news is reported regularly about climate-related impacts happening and possible solutions to address the problem (not unlike today). Students are asked to imagine that a Climate Challenge is announced to give youth a vital voice and role in recommending energy solutions to mitigate climate change by lowering carbon emissions.

In the scenario, students form investigative teams and join the Challenge. In the 6-part investigation, students work on the various Quests to examine the influence of climate on their lives, causes of climate change and possible climate futures by changing the amounts of carbon emissions, fossil fuel consumption and alternative and more efficient energy use. To complete the Challenge, students must find and defend their team's energy solution to the developing climate change crisis.

On their teams, students can play one of six global youth roles whose personal narratives are inspired by real-life climate-related stories. Each role has three lenses that influence students' team participation: a regional perspective, a unique skill set, and awareness about an alternative "clean" energy solution.

The Hot simulation confronts students with real life questions about how to use our best available scientific knowledge to deal with regional and global climate change, carbon emissions building up in the atmosphere, and the central role of energy in our lives and the potential for alternative energy solutions.

The Focus on Energy, Carbon Dioxide and Mitigation Solutions: Several greenhouse gases, in addition to carbon dioxide, are significant contributors to Earth's increased global temperature. These include methane and nitrous oxide, among others. We focus on carbon dioxide because it is the largest contributor to greenhouse gas emissions and its effects on climate last for millennia. Carbon dioxide emissions are mostly due to burning fossil fuels to supply the world's energy. We recognize, however, that other human activities, such as land use changes, also play an important role in climate change. We also recognize that mitigation is not the only approach to addressing the climate change problem- society will also have to adapt to ongoing and future climate change. However, the required level of adaptation will depend largely on the level of mitigation, thus for simplicity, we focus on the latter aspect. By focusing on carbon dioxide, students participating in Hot will be involved in designing solutions to address the biggest driver of recent and future climate change. We believe that their learning at this stage will be better served by developing deeper understanding around a few focused topics.

Goals: Knowing how to investigate the world, solve problems, and develop global understandings are pre-requisites for success today. Also important is the ability to use science to inform the ethical compass we develop to help make choices about difficult problems and to make sense of the diverse media covering them. We think one of the best ways for students to do this, and the approach used in Hot, is to involve students in research-based learning experiences. In the process, we hope that they develop important habits for thinking, perspective-taking, self-management, communication and social engagement that they can use in their personal, professional and civic lives.

Themes: Two questions are central to the Hot simulation: (1) what are the annual carbon emissions reductions needed to meet temperature and cumulative emissions targets for mitigating climate change? (2) what alternative

energies can replace fossil fuels to meet these new targets? By exploring these questions students will work on activities where they encounter five important Hot themes:

1. Problems that are global, like climate change, are inherently complex. Social, economic and environmental circumstances make people more vulnerable than others. Less vulnerable populations can more easily adapt and rebound from climate impacts. When we try to find solutions to global problems, there are usually trade-offs with perceived winners and losers.

2. Global issues like climate change encompass many views. One view is to continue business as usual, focusing on short-term goals and consequences. Another involves a longer view that requires action today for likely benefits and reduced risks in the future. Scientific research helps us by providing quantitative and objective ways to understand a problem, assess benefits and risks, and develop solutions.

3. Big global issues like climate change often make people like feel there is nothing they can individually do to address the problem. This is especially true for most young people. By emphasizing solutions to global climate change, we hope students appreciate that a small group of committed and informed citizens are a powerful force. And, that we have the knowledge and tools to evaluate global problems and find solutions. Also, that they realize there are responsible ways to be actively engaged citizens and make a difference in the world, even when you are young.

4. In this idealized simulation, the playing field is leveled so students have a voice in evaluating information and making decisions about their future. They may become aware of values and develop practices that they can adopt in their own lives for making informed decisions about environmental issues. These might include: applying science to ethical questions, taking diverse perspectives, evaluating costs and benefits, collaborating across disciplines, and considering equity/justice, etc.

5. Students will also gain useful understanding about the crucial connection between global climate and human energy use. They will examine properties of recent and future fossil fuel and alternative energy use, along with the implications of energy-related carbon emissions for climate change, and will be tasked to determine future energy pathways that meet commonly discussed climate mitigation "targets".

Education Standards Addressed: Hot addresses expected student learning included in the following Common Core State Standards (CCSS) and the Next Generation Science Standards (NGSS).

CCSS Mathematics Literacy-Ratios and Proportional Relationships, Interpreting Functions, Numbers and Quantity, Reasoning with Equations and Inequalities and Interpreting Categorical and Quantitative Data.

CCSS English and Language Arts Literacy-Reading Informational Texts, Speaking and Listening and Writing.

NGSS Core Ideas-Weather and Climate, Natural Resources, Human Impacts on Climate and Global Climate Change.

NGSS (Cross-Cutting Concepts)-Patterns, Cause-Effect, and Scale, Proportion and Quantity. *(Practices)*-Asking Questions and Defining Problems, Analyzing and Interpreting Data, Planning and Carrying Out Investigations and Constructing Explanations and Designing Solutions.

Organization of Simulation's Challenge Quests: Each Quest follows a common sequence:

News Report: introduces background and the event(s) or situation happening during the Quest. While we drew on real events and information for news reports, the people and events are all fictitious.

Objectives: identifies expected student learning outcomes.

Get in the Quest - Role play: Activities for students to develop background and skills, including underlying science concepts.

Start the Quest: The progression of tasks in the 6 Quests for students to develop knowledge, make computations acquire data needed to design energy solutions to mitigate climate change by reducing carbon emissions. A guided set of activities and questions for students to examine the results of the Quest investigation and what they are learning.

Reflect: Questions that ask students to consider the implications of the Quest in light of what is being reported in the news and as they think it affects them, their community, the world and their future.

Climate Challenge Portfolio: When this icon appears next to a student task and/or assignment, the student work should be included The Climate Challenge Portfolio will be collected at the conclusion of the final Quest and be an important student performance assessment.

Resources, Data and Digital Tools
***Can be downloaded at http://realworldmatters.org/node/17**

Resources: The main resource for the simulation is Hanover's Climate Portal. Currently this is a searchable Excel spreadsheet with diverse media resources from the Internet on climate change topics and background on each role (climate, impacts, region). Students can use this resource, as well as resources listed in each Quest under "Additional Resources," to gain background.

Data: Most of the Quests require students to perform data analysis.

Digital Tools: To perform the data analysis, an Excel Workbook with several spreadsheet models is available. Students can use these simple models to test hypotheses and ideas for various scenarios to mitigate carbon emissions and fossil fuel use, as well as to see how effective increasing alternative energies are to replace fossil fuels.

THE SCENARIO

Aubrey Vale never thought of her suburban home in eastern Maryland as part of a tropical hurricane belt – until the day Hurricane Lucy came.

Photo credit: Creative Commons, Hurricane Katrina

Over several days in late September, Lucy crawled up the Atlantic coast, finally barreling toward Maryland's Chesapeake Bay and the Eastern Shore. The Vales evacuate with the rest of their town, heading north, to New York, and the safety of Aubrey's grandfather's apartment. It's a good thing too: the full impact of Lucy smashes into the Bay area and Washington, D.C.

Hurricanes, like Lucy, are expected every 100 years. Lucy is the second to hit the eastern U.S. in 5 years. Lucy left a path of destruction that destroyed homes, schools, businesses and communities. More than 30,000 people were forced to relocate while the area rebuilds. Among the "refugees" are Aubrey and her family, now living in New York with Grandpa Jack.

Jack Hanover is affectionately known in the press not as Aubrey's grandfather, but the "grandfather of global warming," a scientist who has spent his career discovering documenting, and educating the public about climate change.

Climate Change Science Realities

When the news about Lucy broke, Hanover was just finishing a presentation to thousands of scientists, attending the Global Climate Summit. Below is an excerpt from Hanover's presentation.

> *Continuing at the present rates of burning fossil fuels to meet the growing global demand for energy will add enough carbon dioxide and other greenhouse gases to the atmosphere to significantly raise Earth's global temperature in the next 2-3 decades, when today's teenagers will be in their 40s. Factors that drive our climate are changing and the world is likely unprepared for the magnitude of impacts we can expect in the coming decades. These include: changes in temperature and precipitation patterns, sea live rise, increasing frequency of extreme weather and other related environmental, economic and social stresses on the planet and all life.*

A Global Band of Friends

Living out of a few suitcases, sleeping on Hanover's couch, attending a new school, and away from her home and friends, Aubrey never imagined events like Lucy could impact her. These disasters were something she only heard about on the news; they happened to other people who lived far away from the comforts of her life on Maryland's Eastern Shore.

Her only escape from the upheaval in her life was a Google Hangout where she meets other teenagers who, like her, are living on the frontlines of climate change. Each teen has a personal story to share about his/her own interests and skills, region of the world and unique experiences. Together, they form a global band of friends:

Jia's family farm was lost to flooding by the release of dam waters and had to transition to new life in a big polluted city
Luis from Brazil relocated after flooding resulted in a mudslide that swept away his home
Albert faced severe and prolonged drought that threatened his family's survival in northern Kenya
Natasha's apartment building in the Russian tundra collapsed as a result of thawing frozen ground (permafrost)
Will in Bangledesh was forced to move after a fierce cyclone caused storm surges that flooded and ruined his family's farm

Climate Science and Solutions – Will's "Hot" Climate Game Idea

Wondering why Aubrey retreats to the basement for so many hours (and at all hours), Grandpa Jack wanders down to see what's up. He finds her engaged in a Google Hangout. After some cajoling, Aubrey convinces Hanover to join in with all of the kids. Most of the conversation is spent identifying climate conditions in the teens' respective regions, what they viewed as normal compared to observed changes. And, peppering one another with questions about what more they needed to know in order to figure out if the events impacting their lives were part of a bigger global climate change story. Hanover thinks, "How refreshingly scientific these young people are in discussing climate change!"

Not realizing he's thinking out loud, Hanover says, "If only more youth could connect like you to evaluate climate change and solutions." Will loses no time telling Hanover an idea to build a massive online climate reality game that thousands, maybe millions of people, could play. The idea would be for players to face real climate stories happening in

the real world, makomg decisions about how to minimize the impacts to people and the environment. It is also to gain the most influence over the human and environmental knobs of climate for all humanity. The game could be called *Hot: One World, One Planet.*

Moved by Will's idea and all the kids' support for it, Hanover decides to go for it. He enlists the help of blockbuster film director, James Merimon, world-renowned economist and global poverty fighter, John Jacks and the famous game developer, Sussie Schell. They develop a game that blurs the lines between the real and game worlds.

A beta version of Hot is ready. Step into the roles of Aubrey and her friends and form a team to test it. Investigate climate change and energy solutions based on events drawn from today's headlines. Evaluate and recommend solutions backed by science. In the final Quest spread your team's solution to people outside the Hot game and convince as many as possible that it achieves the best climate future for the world.

Grandpa Jack, Merimon, Jacks and Schell become the kids' mentors on their 6-Quest journey from curiosity and concern to knowledge and organizing. As students progress through the Climate Challenge Quests, their stories develop along with opportunities to learn alongside the characters they are role-playing.

QUEST ONE:
Developing Climate Crisis-join the challenge

TIME: 1 Class +Homework

Get used to it - extreme weather maybe the new normal

The Category 3 hurricane that devastated Maryland's Eastern Shore last week is just one of several extreme weather events to absorb the resources of the international relief community. This month has also seen a scorching late-summer heat wave in Russia. Droughts in Kenya. Massive flooding across Bangladesh.

What is happening with all the weird weather? Well, according to climate scientist Jack Hanover, we are seeing the new normal for climate. Hanover says his research shows that now after decades of consistent rise in global temperature, the frequency of extreme weather events is increasing. "This is not the natural way Earth's climate behaves," says Hanover. According to Hanover, and the Multinational Climate Science Group, we have been spewing so much carbon dioxide and other greenhouse gases into the atmosphere for so long, that our climate is changing and now we have to start dealing with consequences.

One of the major conclusions from top officials attending a joint meeting this week in Los Angeles is climate change is making people more vulnerable and is evolving into a humanitarian crisis that scientists say we can not ignore.

Objectives

The student will be able to:

- Describe some of the ways climate change is impacting different regions and the people who live there.
- Identify main points in their role's personal story and explain their relevance to the simulation.
- Explain how the three lenses of each team member's role can contribute to your team.

Get in the Quest - Role Play:

Quest 1 Part 1 Aubrey meets Jia, Luiz, Natasha, Will and Albert on a Google Hangout where they talk about "weird" weather happening. Students start learning about the teen roles and select one to play in the Hot simulation.

1. Introduce students to the Challenge as a simulation they are going to conduct over the next 2 weeks. Ask them to consider that the developing climate crisis is really happening along with impacts. They have a rare opportunity to recommend ways to deal with the developing crisis by joining the Climate Challenge.

2. Have students read the Hot scenario online (http://realworldmatters.org/node/17) or as a handout. Discuss the following questions: How do you think climate change might affect you? People around the world? What do you know already about possible causes, impacts, and solutions? What do you want to know? What about the scenario interest you most? What do you want to know more about?

3. Tell students they are going to play one of the six Hot roles on a team. To stimulate a brief discussion about how climate change is influencing life, show the trailer to the film "Climate Refugees," http://goo.gl/oLMyI (3:02 minutes) and/or Planet Nutshell video, "Climate Change Around the World," http://goo.gl/Zfbz4.

4. Have students write short responses sharing their current understanding/thinking on: the difference between weather and climate, causes for rising global temperature, changes occurring that increase global temperature, the relevant time period changes are happening, ways life may change if climate continues to warm, and differences in how climate change might affect people differently around the world.

5. Assign roles and organize teams. Ideally, each team has six students, one student playing each role.

Suggested Homework: Students re-read their roles. They can also re-watch the videos shown in class, as well as look some of the Additional Resources for Quest One. They write a paragraph summarizing the following aspects of their role: Climate conditions impacting your role's life. Most relevant facts about my role's life story. Skills and perspectives my role brings to my team. Energy technology connected to my role's story.

Quest 1 Part 2 Students continue to explore the climate change problem and regional climate differences among the youth they are playing. They also compare climate impacts they are all experiencing and differences in how people are dealing with them. Along the way they should learn how weather differs from climate. They discover where you live matters when it comes to climate change, the scale of climate impacts and the ability (vulnerability) of people to deal with them.

Start the Quest

1. Provide a day for students to research their roles and complete Quest One. A good place to start is Hanover's Climate Portal (http://realworldmatters.org/node/17) where there are many climate-related Internet resources. They may also find additional information on their own.

Students take notes and organize them around the following questions: How is climate changing? Does it affect me? Where is my role's country located? What are the usual or average regional climate conditions - tropical, arctic, grassland, rainforest or other forest or some combination? Is climate changing? What, if any, are the climate impacts and how are people in my region dealing with them?

2. Challenge teams convene to discuss and analyze what they are learning from their role research.

Ask teams to use a class Hot Blog or Bulletin Board to enter responses to the following questions and complete Quest One: What is the difference between climate and weather? How does climate change affect people and regions around the world differently? How would you describe the vulnerability of people and ecosystems in your region to climate change: high, medium, low? What evidence supports this claim? Be sure to cite your source(s). Which roles do you think are most vulnerable? Describe the vulnerabilities?

Reflect

3. Ask students on the teams to share their reactions to the news report at the beginning of the Quest and thoughts on the whether climate change impacts can get worse than they are today. If so, how?

Suggested Homework: Read "Understanding the Science" and respond to the related questions.

Understanding the Science	**Think About It**
According to the Intergovernmental Panel on Climate Change, "Vulnerability to climate change is the degree to which geophysical, biological and socio-economic systems are susceptible to, and unable to cope with, adverse impacts of climate change. The term 'vulnerability' may therefore refer to the vulnerable system itself, e.g., low-lying islands or coastal cities; the impact to this system, e.g., flooding of coastal cities and agricultural lands or forced migration; or the mechanism causing these impacts, e.g., disintegration of the West Antarctic ice sheet…vulnerabilities are associated with many climate-sensitive systems, including, for example, food supply, infrastructure, health, water resources, coastal systems, ecosystems, global biogeochemical cycles, ice sheets, and modes of oceanic and atmospheric circulation."	What regions and countries do you think are vulnerable to climate change? Why? Can you think of any examples of impacts today that might be connected to climate change that reveal the vulnerabilities of people and the environment?

Additional resources:

BBC News: "In Pictures - How the world is changing", http://bbc.in/12cSiBq, provides regional overviews.
Union of Concerned Scientist: "Climate Hot Map", http://www.climatehotmap.org.
NASA: "The current and future effects of climate change", http://climate.nasa.gov/effects.
Article by Dr. Jeffery Sachs, "Climate Change Refugees," http://goo.gl/HUHts.

QUEST TWO:
Push and Pull of Energy and Carbon in Our Lives

TIME: 2 Classes +Homework

We love our carbon diet – but for how long?

Two big numbers for the planet came out today. The first, atmospheric concentrations of carbon dioxide (CO_2) temporarily reached 400 parts per million (ppm). The last time CO_2 levels were this high was probably several million years ago. Why does this matter? Well Earth looked a lot different – it was even warmer (by several degrees) than today and sea level was up to 80+ feet higher. The other big number comes from the International Energy Agency that projects fossil fuels have provided 80% of human energy supply in recent decades. Scientists agree our mostly carbon diet to power and advance our lives is taking the world to dangerously high levels of CO_2 that are causing significant global warming. All this extra energy is helping to set in motion some huge changes like melting ice sheets and glaciers, thawing permafrost, and rising sea level. On every continent we find crazy weather and stories linked to climate change. Is it time for a low-carb energy diet?

Objectives

The student will be able to:

- Examine historical global temperature and atmospheric carbon dioxide trends
- Interpret energy and atmospheric CO_2 data to recognize factors related to regional trends/differences
- Write a team definition of the climate change problem including some of the underlying science.

Get In the Quest – Role Play

The Quest: Study trends in global temperature and atmospheric carbon dioxide. Learn about the affects of burning fossil fuels for our energy on the amount of atmospheric CO_2 and on global average temperature. Explore energy uses in your role's country and compare them to the U.S. and other students/roles on your team.

1. Ask students to think about their everyday lifestyle activities that use energy and consider how this might differ from the Hot role they are playing. Suggest that they think about energy use in the following categories: home, work, play, school, consumption (eating/buying), and trips.

2. Watch the Planet Nutshell video: "Where Does Carbon Dioxide Come From" (http://goo.gl/XWFMP).

3. Possible discussion questions after the video: How much energy do we need? What can you do without energy? What might be similarities and differences in energy use between you and your Hot role? How does our access to energy influence our lives? What global changes in energy use might occur in the future?

Start the Quest

Working in their teams, students are going to quantify how climate is changing by calculating the rate of change for two important factors (average global temperature and atmospheric carbon dioxide) for two periods: 1951-1980 and 1981-2012. Compare the rates of change. By how much are they different? (Express in terms of a % difference). Show your calculations.

DATA: For CO_2 use: http://www.esrl.noaa.gov/gmd/ccgg/trends/global.html#global_growth. Note data start at 1959 so calculate the rate of change for 1959-1980. For temperature use: http://data.giss.nasa.gov/gistemp/graphs_v3/Fig.A2.txt.

Suggested Homework: Students can calculate their individual carbon footprint using a tool on The Nature Conservancy web pages http://goo.gl/twws2 or one provided by the U.S. Environmental Protection Agency (EPA), http://goo.gl/XArrz. Respond to the following: What is meant by a person's carbon footprint? How does your carbon footprint compare to the average person in the U.S., the world, to your role and other Hot roles? Which roles do you think come from regions that are the largest energy consumers? Why?

With your team, use data found below (and via your own research) to prepare a short report that digs deeper into global and regional trends in atmospheric CO_2 and energy use. Be sure to include the regions represented by the roles on your team. If possible, support your findings with graphical data/evidence.

DATA Carbon Emissions and Energy data is available at Environmental Protection Agency's "Global Greenhouse Gas Emissions," http://goo.gl/6tVMI. U.S. Department of Energy "Carbon Dioxide Information Analysis Center," http://cdiac.ornl.gov/trends/emis/meth_reg.html and U.S. Energy Information Agency, http://www.eia.gov/countries/.

Some suggested student questions and calculations include: What are 5 cause-effect relationships that influence atmospheric CO_2? What are the main sources of carbon emissions (natural and human) and related economic sectors? What are the main energy sources in your role's country? What are regional differences in energy use and carbon emissions? How might the biggest carbon emitters change in the future and why?

Team discussion and entries on Hot Blog or Bulletin Board: To complete the Quest, draw on your learning so far and your role's perspective to write a team definition of the climate change problem and consider the question, "Is it time for the world to get on a low carbon diet?" Some things students may want to consider: What do mean by climate change? How are our lifestyles related to the issue of climate change? In your opinion, is there enough climate change evidence to support taking action to mitigate (reduce) the problem? Justify your opinion. Do you need to learn more before making this decision? If so, what do you need to know? What kinds of lifestyle changes might people make to mitigate climate change? Are there changes you would be willing to make to reduce your energy consumption?

Reflect

Students react to the Quest Two news report and exchange reactions with other students on their team. They reflect on the questions: What individual actions might your take to reduce your energy use and carbon footprint? Do you think individual actions can help avert the climate change crisis? Why is energy the fuel of civilization?

Suggested Homework: The assignment is to learn more about non-renewable sources for our energy. Students read: "Understanding the Science," watch: the video "Putting Energy to Use," http://youtu.be/J4gnfV7rz-4 (2:14 minutes) and then answer the related questions. Students can also view some of the Additional Resources for Quest Two.

Understanding the Science	Think About It
There are three main types of fossil fuels – coal, oil and gas. They started forming hundreds of millions of years ago, during a time in Earth's climate history called the Carboniferous period. The average global temperature during this period ranged from 68°F to 54°F and the levels of atmospheric CO_2 ranged from 1500 ppm to 350 ppm (for perspective, the current CO_2 level is 395 ppm and global average temperature is about 59°F.) The average climate conditions in the beginning of the Carboniferous were hot, humid and wet and by the end were dry and cold. Earth's landscape that was covered with lush vegetation and coal-bearing swamps. As plants and microbes died, they sunk below Earth's surface and oceans, covered by millions of years of sediments. Over time the dead organisms transformed into coal, oil and gas that we extract today and burn for energy – thus the name fossil fuels. These non-renewable fossil fuels (coal, oil and gas) are currently our main energy sources. For the past 150+ years as global population and technological and scientific advancement exploded, so did our energy use. We now know very clearly that global warming over the past half-century is mostly attributed to increasing greenhouse gas emissions from burning fossil fuels – most importantly CO_2. By increasing the concentration of atmospheric CO_2, we are enhancing the Greenhouse Effect that naturally warms our planet. Here's the strange push and pull of energy and carbon. They both literally fuel civilization. Yet, our dependence on carbon-based fossil fuels is creating the global climate change crisis.	"Follow the carbon". How did this element come to play such an important role in civilization? Are fossil fuels an unlimited natural resource? Where do they come from? Will they ever run out? How do we put fossil fuels to use? How does human respiration compare with fossil fuel combustion?

Additional resources:

Earth: The Operator's Manual Powering the Planet, http://video.pbs.org/video/2229344967 (53:11 minutes)
Intergovernmental Panel on Climate Change: Frequently Asked Questions, http://goo.gl/VABO4
TEDTalk video by Dr. James Hansen: "Why I Must Speak Out," http://youtu.be/fWInyaMWBY8 (17:52 minutes).
CO_2 Now, http://co2now.org

QUEST THREE:

CO_2 Balancing Act: reduce atmospheric carbon dioxide

TIME: 2 Classes +Homework

The Governor in Texas just issued new statewide restrictions on water use as the state suffers through its worst drought in 80 years. Most of the U.S. and Western Europe are sweating through their hottest summers on record. A new study published in the Earth Journal says we better get used to the heat: More atmospheric CO_2 will likely mean more extreme weather.

Just what the world's target should be for atmospheric carbon dioxide is the $50 million question. It's an active area of climate research. Scientists and environmental groups propose various targeted levels for atmospheric CO_2, each associated with a band of possible global temperatures they believe supports a sustainable climate future. Most of the proposed targets are within the 350-750 ppm range. But on which one should we bet our children's future and that of future generations?

The Multinational Climate Research Group says stabilizing atmospheric concentration of CO_2 to 450-500 ppm and a 2°C increase in global temperature above pre-industrial levels is the upper limit before we dramatically change conditions for life. Others, like the Organization of Climate Scientists and People for the Planet, argue that 350 ppm and a 1°C increase is what's needed to avoid dangerous climate change.

An influential group of CEOs, policy-makers and citizens acknowledge global warming but say we can withstand higher targets like 750 ppm and global warming of 3°C or more. "Civilization has always adapted. Climate change is an engineering problem. We can find energy solutions to manage changing climate," said Max King, chairman of the group, Citizens for American Prosperity.

Objectives

The student will be able to:

- Assess the need for action to reduce atmospheric CO_2 concentrations based on scientific research.
- Select a team target level of cumulative atmospheric CO_2 emissions for the world to meet.
- Use an Excel spreadsheet model to find the % annual CO_2 emissions cuts needed to meet your team's cumulative emissions target and to compare the effects of % annual cuts.

Get in the Quest

The Quest: Teams learn about various proposed targets for atmospheric CO_2 and the associated increases in global temperature and predicted impacts. Based on their research and their thinking about action needed to mitigate climate change, teams develop a future carbon emissions scenario.

1. Students engage in the research for this Quest by reviewing several resources: Scientific American article, "What's the Right Number to Combat Climate Change?" http://goo.gl/BPlrF, National Academy of Science paper, "Climate Stabilization Targets," http://goo.gl/LrrVU and the Intergovernmental Panel on Climate Change "Key Impacts as a Function of Increasing Global Temperature," http://goo.gl/CTok1.

Notes should be taken on the following questions and any other information students think is important. What are the various carbon targets proposed and which arguments do you think are strongest? What are the various impacts scientists predict will accompany increasing global temperatures associated with the each target? What do you think will happen if no action is taken to slow the growth of atmospheric carbon?

Teams reconvene to organize and discuss their research. The goal is to identify what students see as the pros and cons of arguments for each target. They can think about such criteria as: predicted impacts associated with the warming scientists expect with various levels of CO_2 concentrations, up-front costs vs. long-term benefits associated with each target, and the certainty and/or confidence they have in climate predictions, and the risks they and others might be willing to take.

Start the Quest

Each team is going to develop its own scenario for cutting global carbon emissions. Teams select a target level for cumulative carbon emissions they think the world should meet based on their research. Have the teams prepare 3-5 statements justifying their target with research and expert opinions.

1. To complete the Quest, teams are going to compute the annual cuts in carbon emissions needed to meet the team's target. Begin by having students download the Excel file in Data and Tools below.

2. Review the spreadsheet set up with students and the methods described.

   Data and Tools:

   The Quest 3 Excel File: "Hot_CO2.Emissions .and.Mitigation.Scenario_2000.2050" can be downloaded from Data and Tools at http://realworldmatters.org/node/17. This Excel workbook is the Climate Change Challenge Data Analysis and Modeling Tool that students will use in each of the remaining Quests. It contains four spreadsheets to model various climate and energy scenarios, make computations and conduct data analysis. The first spreadsheet, labeled "global_aggregate_FF_emissions", is the one used for this Quest. It is a simple model that allows you to try out different annual cuts in CO_2 emissions to see if they will achieve your team's cumulative carbon emissions target by 2050. You can also try out different years to start making the cuts.

   Set-up of the Excel Spreadsheet:

   First column is the "Year."

   Second column is "Global Fossil Fuel CO_2 Emissions." This is the Historical (2000-2012) and the Projected (2013-2050) combined global fossil fuel (coal, oil and gas) emissions in units of gigatons of carbon. The Historical data is based on measured carbon emissions. Projected data will be determined by the selections made by students. See additional notes in the Excel file.

Methods: run experiments with the spreadsheet model

3. Try out different scenarios by changing the number in the cell under the title "% Annual Cuts." As noted within it, the spreadsheet students are going to download reflects a specific example in which emissions increase annually by 2%/year from now (2013) until 2015, then decrease annually by 5%/year from 2016-2050 (the 2% value is roughly the average annual growth rate of emissions in recent years).

4. Students should try starting the cuts in at least 3 different years that are at least five years apart – for instance 2013, 2020 and 2030. This allows students to see the effects of delaying the timing of CO_2 emissions cuts. If students look at the end of column two in the row titled "Cumulative" they can see if the cuts they made meet the team's carbon emissions target by 2050.

5. Students continue adjusting the value used for % annual cuts until you find the right value needed to achieve the team's carbon emissions target.

As student teams run their experiments, have them analyze their results to explain:

- What year did your team decide to start trying to make carbon emissions cuts? Why?
- What are the annual percent cuts needed to achieve your team's emissions target?
- Compare the difference between the emissions in 2009 and 2008. What do you think was the impact of the Fall 2008 Global Economic Crisis in terms of how it impacted the % annual change in carbon emissions in 2009? What was the % change in carbon emissions after the global economy started to recover in 2010? What factors do you think caused these changes? (Hint for students: how are emissions tied to the economy?)

- What happens if the world keeps postponing CO_2 emissions cuts? Explain your answer in terms of your values for % annual cuts in the 3 different start years you selected. Keep in mind that the larger the % annual cuts needed to meet your target, the more difficult they will be to achieve.

Reflect

In their teams, have students share their reactions to the Quest news report. Ask them to discuss what they think needs to happen in order to get consensus around a global target. Do they think this is possible? What are obstacles and opportunities?

Suggested Homework: The assignment is for students to read, "Understanding the Science" and respond to the related questions.

Understanding the Science	**Think About It**
Earth's atmosphere is made up of mostly nitrogen and oxygen. Carbon dioxide makes up less than .4% of atmospheric gases yet it plays a major role in maintaining our planet's habitable temperature. Now we know increasing CO_2 emissions, mainly from the burning of fossil fuels, are causing CO_2 to build up in our atmosphere, thereby, playing a major role in global warming. CO_2 and other greenhouse gases (methane, water vapor, ozone and nitrous oxide) are emitted through both natural processes and human activities. The situation we are in today is that human activities are adding to the concentration of these gases all over the planet – land, air and oceans – and changing the balance of CO_2 coming in and out of the Earth system. Various scientific studies show that limiting cumulative CO_2 emissions is the most important way to minimize future global warming. This is because CO_2 has the largest effect on climate of all the human-made greenhouse gases and because its warming effect lingers in the atmosphere for thousands of years after it is emitted. One way to think about what's happening with CO_2 in the atmosphere is through a bathtub analogy. The bath (Earth's atmosphere) is filled with a certain amount of CO_2. When we turn on the faucet more CO_2 starts flowing into the bathtub. The drain is open but the flow rate of CO_2 coming into the bath is much faster than the rate at which the small drain can remove the CO_2. So CO_2 starts filling up and accumulating in the tub. In order to prevent the bathtub from overflowing, we have to find ways to stop or reduce the inflow of CO_2 early enough.	View the various simulations on the Climate Bathtub Model of Earth's Carbon Cycle, https://spark.ucar.edu/node/2749. ▪ How are humans influencing the carbon cycle? ▪ What do we mean by net increase in atmospheric CO_2 concentrations? ▪ Why does this influence Earths temperature?

Additional resources:

CO2 Now, http://co2now.org
National Geographic's: "Climate Milestone," http://goo.gl/xkyp6
"NASA Scientists React to 400 ppm Carbon Milestone," http://climate.nasa.gov/400ppmquotes/
"How the World Can Tackle Climate Change," http://goo.gl/AM5iJ

QUEST FOUR:

Say Goodbye to Business as Usual-cut fossil fuel use

TIME: 2 Classes +Homework

The bi-partisan "Gang of 10," U.S. Senators today sponsor a bill calling to end government subsidies to the fossil fuel energy industry and put a carbon tax on petroleum fuels. "Global climate change is not a Republican or Democratic issue – it is an issue for American leadership," said Senator Tom Williams of Utah. "There are at least three certainties if we continue 'business as usual' -- powering our lives with fossil fuels.

First, at some point these non-renewable, finite energy sources will become scarce and eventually run out. Second, the amount of atmospheric carbon dioxide accumulating in our atmosphere will grow. Third, the planet will continue to get hotter and the impacts of this warming will become widespread and very disruptive."

It seems this is the week for unlikely alliances. James Merimon, director of two of Hollywood's biggest grossing movies, "Andria Doria" and Clone," announced he was jointly financing a campaign with ultra conservative radio talk show host, Joe Parker, to end fossil fuel subsidies and promote a carbon tax. The two men say removing the subsidies and adding the carbon tax will achieve a fossil fuel price that reflects their impacts on climate and human health. It would also allow alternative clean energies to compete more fairly. Citing analysis of British Columbia's carbon tax, Merimon promised the plan would "significantly reduce fossil fuel use and lower greenhouse gas emissions, without hurting the economy."

Responding to a question about the new air of bipartisanship blowing through the Capitol, President George Chase said he applauded efforts to make progress on the important issue climate change. However he also told reporters "we have to think before we start making a villain out of one of the biggest contributors to the U.S. economy – the fossil fuel industry."

Objectives

The student will be able to:

- Identify 3-5 factors to consider in reducing global fossil fuel use
- Use an Excel spreadsheet model to investigate and calculate the annual cuts in fossil fuel energy supply
- Demonstrate how using science and math informs environmental decisions

Get in the Quest

The Quest: Students are going to compute the level of fossil fuel energy supply reductions needed to achieve their team's atmospheric CO_2 target. They face such questions as: How would life change by implementing these reductions? What would replace fossil fuels? What factors are most important to consider in the decision to continue business as usual global energy habits versus cutting fossil fuel use?

1. Introduce Quest 4 and briefly discuss students' ideas about factors to think about before cutting fossil fuel use.

2. On each team, students assign one of the materials listed below to one person to read/view. The materials represent diverse expert viewpoints on energy and climate. A team discussion should follow around such questions as: How is science and math used to support, refute or cast doubt on claims? What factors are identified to consider in deciding whether to reduce fossil fuel use? Should fossil fuels be part of our team's energy solution and why or why not?

   - "Exxon CEO Advocates Emissions Tax", http://goo.gl/bavgd
   - "Transcript from President Obama's Climate Change Speech", http://goo.gl/kYCWI
   - "Warming Threatens Africa Food, Asia Water Within a Lifetime", http://goo.gl/GI6rB
   - "UN Urges Deeper Pollution Cuts In Biggest Challenge for Humanity", http://goo.gl/7IkBx
   - "Power for the World's Poor More Pressing than Emissions Cuts", http://goo.gl/GEqjT.
   - "Energy Expert, Daniel Yergin's PBS Interview, http://goo.gl/YWEw2 (8:23 minutes)

Start the Quest

1. Each team is going to compute the annual cuts in fossil fuel energy supply needed through 2050 to achieve the team's target.

2. To begin, have students download and review the Excel file in Data and Tools below, and discuss the methods.

   Data and Tools:

   Excel File: "Hot_CO2.Emissions.and.Mitigation.Scenario_2000.2050" can be downloaded from Data and Tools (http://realworldmatters.org/node/17). Look at the second worksheet, labeled "FF_emissions_energy_by_source." It contains a simple model to find the right amount of annual cuts needed in fossil fuel energy supply to achieve your team's cumulative carbon emissions target.

   Set-up of the Excel Spreadsheet:

   First column is the "Year."

   Columns B-E contains the total global fossil fuel CO_2 emissions from all 3 fuels for each year. As with the previous exercise, after you select a peak emissions year, you will have to apply the appropriate formulas using the % increase and % cuts values. (The latter should match the numbers you chose on worksheet 1.) The difference is, in this case you must apply the values to each fossil fuel. In other words, **you will need to change the formulas in columns B-D** (column E is simply the sum of these columns – it should be exactly equal to the values in column B from the previous worksheet. *Column F* shows the % year-to-year change in the emissions so you can check your work.

   Cells N1-P4 show the conversion factors that will be needed to do the energy supply calculations. These values tell us the ratio of energy to emissions for each fuel type. **Do not change these**.

   Columns J-M show the results of converting the emissions values into energy supply values.

   Column N contains the values you calculate for the "energy deficit".

Methods: run experiments with the spreadsheet model

Apply the % increases and % cuts to each fuel's emissions in columns B–D. Do this for each peak emissions year you pick. Use the formulas contained in the cells of the example spreadsheet you downloaded. Check the cumulative emissions value again (this time at the bottom of column E) – this should match the value from the previous worksheet. If it doesn't, carefully check your formulas.

Convert the emissions values into energy units. To do this, use the conversion factors described above. These factors are based on data from recent reports from the Intergovernmental Panel on Climate Change (IPCC) and the International Energy Agency (IEA). To make the conversion, use the formulas contained in the example spreadsheet – basically you are simply multiplying all the emissions numbers by the energy conversion factors.

Calculate the "energy deficit" for each year after the peak year. See the numbered notes in this worksheet for instructions on how to calculate these values. As the notes explain, these values represent the energy supply needed each year from alternative (non-fossil) energy sources as a result of the cuts in fossil fuel energy supply.

As teams run their experiments and afterwards, have them analyze and write up their results to find the following:

- As shown in cell S15, total global energy supply (from all sources) was about 532.5 EJ in 2010, according to the IEA. What was the total amount of energy supplied by non-fossil fuels? (Hint: Use the value in cell M16.) Using this value, calculate the proportions (percentages) of the global energy supply that were supplied by fossil fuels vs. non-fossil fuels.

- For each scenario you pick, how much does the energy deficit, i.e. the total alternative energy supply needed, change from the first post-peak year to 2050? Show your work.

- What happens to the energy deficit the longer we wait to start the cuts? Does this mean we would need more or less energy from alternative sources to match the deficit?

- How do the amounts of total energy supplied by fossil fuels vs. non-fossil alternatives in year 2050 compare to the amounts you calculated in year 2010 above? Show your numbers.

Reflect

In their teams, students share reactions to the news report. They discuss questions listed in "The Quest" on page 14.

Additional resources:

International Panel on Climate Change, "Mitigation of Climate Change: Fossil Fuels", http://goo.gl/4bC7k
"What is Vote 4 Energy", http://youtu.be/6FZF-YGZjzs (2:24 minutes)
Bloomberg.com Energy web pages, http://goo.gl/8ogG8
GRIST "The positive economic impact of the carbon tax," http://wp.me/plpRp-N3E

QUEST FIVE:

Powering the World – energy solutions to mitigate climate change

TIME: 3 Classes +Homework

Next year, New Yorkers are going to get a very different view of the Hudson River. Thanks to a deal between the Mayor and the company, Blue Water Wind, 200 wind turbines are going to add to the scenery and provide an estimated 350,000 homes with power. The planned wind farm is expected to replace nearly 2 million tons of carbon emissions annually. While some New York and New Jersey residents are upset about the changing landscape, the Mayor is getting mostly praise for his efforts to fight climate change and help create more than 1000 new "green" jobs in the city.

The wind farm is just one of many "green" projects the Mayor has cooking. He and John Jacks held a meeting at Columbus University that brought together 100 mayors from some of the largest global cities to discuss and agree to measures to increase the use of alternative energies and to improve energy efficiency. Alternative or renewable energies include: wind, solar, geothermal, hydroelectric, sustainable biofuels, and nuclear. According to the International Energy Agency, renewable energies are growing at a rapid rate and are now in second place (including nuclear energy) as the biggest source of electricity behind coal.

In an address to the group British physicist, David Mack, encouraged the Mayors "at the end of the day our choices about energy and climate are largely about numbers. We need numbers to decide if solutions are going to work. They help us to answer some very practical questions such as how big an increase do we need in alternative energy to replace cuts in fossil fuels and can we supply enough power through alternative energies to meet the global demand?"

Objectives

The student will be able to:

- Identify energy choices to mitigate climate change, including: alternative energy and improved efficiency.
- Use an Excel spreadsheet model to calculate the annual increases in alternative energy supply needed to replace the fossil fuel cuts made in Quest 4.
- Research and make calculations to get a sense of the reasonableness of various energy solutions
- Describe energy solution recommendation based their research and explain how it mitigates climate change

Get in the Quest

The Quest: Now teams are ready to find the percent annual increases in alternative energy solutions needed to replace the fossil fuel cuts calculated. Be prepared to defend your team's solution with science and numbers.

Part 1 Gain Background on Alternative Energy Solutions

1. In their teams, students watch Dr. David MacKay's TEDTalk " How the Laws of Physics Constrain Our Sustainable Energy Choices," (18:48 minutes). The video should be paused in different places to discuss such questions as: How hard or easy do you think it is to change our energy habits? Which alternative energies do you think have the greatest potential to replace fossil fuels and why? Will all the world's energy be easily supplied by renewable energy, nuclear power and improved efficiency, or will it be very challenging? Should both renewables and nuclear be part of the near-term global energy solution (until 2050)?

2. Each student playing a Hot role has an energy solution associated with his/her story and it is his/her job to become the resident team expert on this energy solution. To do this, students can conduct research, using resources on Hanover's Climate Portal as well as ones in the "Additional Resources" for this Quest and other sources they locate.

3. The outcome of the research should be a 1-2 page energy fact sheet on their energy solution, addressing:

- How does it work or how is energy produced from it?
- Where is it found how do we get it?

- Which countries are big users of this technology?
- What is the recent trend in its energy use and current proportion of energy supply?
- Can you quantify the ability of the solution to produce energy in units of energy, e.g., how much energy is produce by 1 average sized wind turbine in a day?
- What are benefits and/or negative consequences (risks) of using it?

Suggested Homework

Students read, "Understanding the Science" and answer the related questions. The also read the energy fact sheets developed by each of the students on their team.

Understanding the Science	**Think About It**
Read David MacKay's analogy to explain power from his book "Sustainable Energy – Without the Hot Air." "Power is the rate at which something uses energy…If you want a drink of water you want a volume of water – one liter perhaps. When you turn on the tap, you create a flow of water – one liter per minute, say…The volume delivered in a particular time is equal to the flow multiplied by the time…flow is the rate at which volume is delivered…you get flow by dividing volume by time… Energy is like water volume - power is like water flow…For example, whenever a toaster is switched on, it starts to consume power at a rate of one kilowatt….the toaster consumes 1 kilowatt-hour of energy per hour (kWh); it also consumes 24 kilowatt-hours per day."	After reading Mackay's analogy, answer the following questions: What quantitative information do you think is important to know about energy solutions in order to evaluate their effectiveness for mitigating climate change? Be sure to think about fossil fuel energy supply amounts vs. alternative energy supply amounts. What information do you think is important to know about energy demand and supply? Why do you think fossil fuels supply the vast majority of the world's energy?

Part 2 - Start the Quest

1. Each team is going to compute the annual increases in energy supply from alternative (non-fossil) sources to replace the fossil fuel cuts they calculated in the previous Quest.

2. To begin, have students download and review the Excel file in Data and Tools below, and discuss the methods.

   Data and Tools:

   Excel File: "Hot_CO2.Emissions.and.Mitigation.Scenario_2000.2050" can be downloaded from the Data and Tools http://realworldmatters.org/node/17. Look at the third worksheet, labeled, "alt_energy_by_source". It provides a simple model that allows you to try out different annual increases in alternative energy sources/practices needed to replace fossil fuels in the amount needed to achieve your team's cumulative carbon emissions target. The file includes measurements of recent energy supply by alternative sources from the International Energy Agency.

Team Assumptions
The amount of fossil fuel energy supply reduced in a given year can be matched by corresponding increases in energy supply from a combination of the various non-fossil fuel alternatives. *Energy efficiency can match up to half of the energy deficit calculated in the previous quest.

Set-up of the Excel Spreadsheet

Columns B-E show the global energy supplied by each fossil fuel for each year.

- As with the previous exercises, the example spreadsheet reflects the case in which fossil CO_2 emissions (and therefore energy supply) peak in 2015. After you select a different peak emissions year and perform the calculations in the previous quest, the energy supply values and energy deficit values in this spreadsheet will get automatically updated.

Columns H–W relate to the alternative energy supply levels you will calculate in this quest.

- See the notes within the spreadsheet, and the formulas within the cells in these columns, for further instructions on how to do these calculations (as well as assumptions used in the example spreadsheet). As explained therein, after assuming that energy efficiency can match **up to half** of the energy deficit in a given year, each team must decide on a particular mix of alternative energy sources that will make up the rest of the energy deficit value in that year. In order to do this, **you will need to change the values in columns H, J, M, P, and S** – i.e., the columns labeled "% (fraction)".

- The spreadsheet model will then automatically calculate the resulting supply amounts for each fuel (as well as all other values you'll need from this spreadsheet). Column V ("total non-fossil supply") contains the sum of these supply columns – each value in this column should be equal to the energy deficit value in the same year.

- The columns labeled "% increase vs. 2010" show the increase in the energy supplied by each alternative source relative to the amount in 2010 for each source. In order for users to assess the magnitude of the changes over time, these values are calculated for four years: 2020, 2030, 2040, and 2050.

The last worksheet in the Excel file, labeled "alt.energy.trends_2000.2010", contains the annual amounts of global **electricity** supplied by the various alternative energy sources between years 2000–2010, as well as the year-to-year changes in these values. These supply values are from the U.S. Energy Information Administration (EIA – see link in spreadsheet). They are provided so that teams gain insight into recent trends in alternative energy sources in the real world.

Questions for students to answer based on their calculations and data analysis:

- Which alternative energy sources show the greatest increases in energy supply in your scenarios? Describe this quantitatively by analyzing your values for the columns labeled "supply".
- Which sources show the greatest long-term increases relative to their supply values in 2010? Analyze the columns labeled "% increase vs. 2010" to answer this.
- Using the EIA data on the last worksheet (see instructions above), which alternative energy sources show the greatest increases in recent years in the real world? How do the trends you've just analyzed in your scenarios compare to these real-world trends?
- Based on your findings, do you think your energy substitution scenarios are realistic? In other words, if you find very large differences between the real-world trends and your calculations, do you think your scenarios are reasonable? For instance, would your scenarios at least implicitly depend on some sort of major, almost revolutionary-scale changes? Bear in mind that all large-scale changes in the world's energy supply mix would be challenging – but what you need to explain is whether you think your scenarios would present near-insurmountable challenges.

Part 3 – Develop the team's energy solutions

1. Students in each team brief each other on the energy fact sheet they developed. The team discusses the pros and cons of solutions. Review the amount of decrease in fossil fuel use the team calculated in the previous task.

2. Based on information presented, teams start to consider the evidence they have to evaluate the potential effectiveness of each energy solution – wind/solar/geothermal, nuclear, bioenergy/waste, hydropower, and energy efficiency - to replace fossil fuels energy supply and therefore and mitigate human-caused climate change. The idea is for each team to decide on a "best course" based on thoughtful analysis of their findings.

3. Teams should write up a description of the methods and criteria they use to evaluate the various solutions scenarios they developed. Their explanation should focus mainly on quantitative analysis, i.e., numbers whenever possible to support their claims and to present evidence about the realism of their scenarios. Also, remind them that their recommendation can included more than one solution.

Reflect

Students share their reaction to this Quest's news report and discuss why it is important use science and math to inform environmental decision-making around such issues as global climate change.

Additional resources:

NOVA's film, "Power Surge," http://goo.gl/E1774 (53:07 minutes)
PBS series, "E2 Energy," with episodes dealing with various solutions, http://www.pbs.org/e2/energy.html
"Clean Energy" from The Union of Concerned Scientists, http://www.ucsusa.org/clean_energy/
Carbon Tax, http://wp.me/plpRp-N3E
We need something on adaptation
U.S. Energy Information Agency (EIA) web pages: http://www.eia.gov/kids/ and http://goo.gl/mozXT.

CLIMATE CHANGE CHALLENGE

Presentation Rules

TIME: 2 Classes +Homework

Some of our favorite stars from music and film are expected to come out to support Jack Hanover, James Merimon, John Jacks and Susie Schell for the premier and release of their new online and mobile game – Hot: One World, One Climate.

What brought this influential braintrust from entertainment, science and policy together? According to Merimon, who financed the venture, "we wanted to find away to engage people the world-over in deciding what to do about global climate change and its impacts, especially young people."

Jacks, the Columbus University economist best known for his working fighting global poverty says, "we wanted to create a place where young people have a real say about how we go about solving this global issue that directly affects their future." The game guru who designed Hot is Susie Schell. "We've been testing Hot with young people. Hot is a fun, open and social game space to learn about an important global issue, crowd-source ideas and choices and create big a grassroots movement campaign for change based on our best research knowledge." At a news conference, Hanover showed up with six young people (including his granddaughter). "Today's premier presents the experiences and solutions these youth came up with by testing out all the Climate Challenge Quests in the Hot Game."

Message To Students:

You and your teammates just finished the Five Climate Change Challenge Quests. You learned about our best available climate science, and applied it along with math and technology skills to describe possible energy solutions to mitigate the impacts of global climate change. Now its time for your team to use it's creativity and knowledge to present the solutions you think can responsibly and sustainably power the world in the 21st Century and beyond.

The Rules

Students should get familiar with the four rules for the presentation before they get started. For schools that have the technology, you can encourage students to create a web page to upload their team's work.

Rule 1: Prepare a 1000 word essay that explains your team's energy solution supported by scientific evidence. The essay should show the breakdown of energy resources and how well it meets energy demand projection period you chose and your team's atmospheric carbon emissions target.

Rule 2: Produce a 3-5 minute presentation on the process (methods) your team went through to develop its energy solution and that educates the public about the solution in a compelling, evidenced-based manner. The presentation format can be oral with visual elements, a video, poster, and/or use software, like Power Point.

Rule 3: On a day designated by your teacher, spread your solutions to other youth using social media like Facebook or Tumblr, if it is available, or some other mode of communication approved by your teacher. Prepare a plan to educate as many of your peers as your can about what you learned about climate change and what you think is the value of your team's solutions. Accurately and honestly report the numbers of people you reach.

Rule 4: All the students playing each of the Hot roles on the team must participate. Show how the team considered the views, perspectives and "lenses" of each role in the presentations.

Bonus: Students may write a short description of their idea for developing Hot as an online or mobile game.

Presentation Evaluation and Grading

A presentation rubric will be developed. Students will use the rubric for a self-assessment, as well as to evaluate their peers. Teachers may also want to use this rubric for grading purposes. The developers of Hot are also interested in the possibility of and ideas for effectively involving a group of scientists in commenting on students' work posted online. Criteria to develop for the presentation rubric include:

- Shows that the team completed all the Quests and associated work
- Methods and approach used to research and design the energy solution
- Unique contributions of individual team members
- Quality of analysis
- Demonstrates STEM knowledge and learning objectives for each Quest are met
- Appropriate use of expert opinion
- Use of scientific evidence to support claims and energy solutions
- Effectiveness in addressing guiding questions for each Quest
- Convincing, clear, compelling and creative arguments are presented

Additional Resources

Tony Leiskowitz Yale, http://youtu.be/PZwgOdVpydU
Jesse Schell, Games for Change 2011 Presentation, "Make Games, Not War," http://vimeo.com/25681002